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SEED AND SOIL INOCULATION

FOR

LEGUMINOUS CROPS.

BY

W. B. BOTTOMLEY, M.A., Ph.D.,

Professor of Botany in King's College, London.

Price, ONE SHILLING.

1907.

"COUNTRY LIFE," TAVISTOCK STREET, LONDON, W.C.

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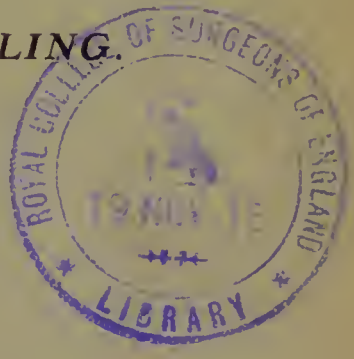

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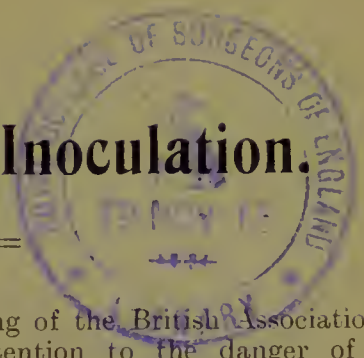

SOME few years ago, at a Meeting of the British Association. Sir William Crookes called attention to the danger of a nitrogen famine in Agriculture, and predicted that within thirty or forty years there would be a general starvation among the bread eating nations, owing to the exhaustion of the nitrogen of the soil, unless some means were devised for procuring more nitrogen for the cultivation of wheat.

There are ten essential elements of food necessary for the healthy development of a plant. Seven of these are generally present in the soil in far greater abundance than is required to supply the small amounts necessary for plant growth. The remaining three elements —nitrogen, phosphorus and potassium—are however present in most soils in strictly limited amounts, and as plants require these in considerable quantities constant cropping of the land soon exhausts the soil, and the farmer has to restore these elements to his soil in the form of natural or artificial manures.

An average of the results of 49 analyses of typical soils in America showed that the first eight inches of surface soil contained per acre 2,600 pounds of nitrogen, 4,800 pounds of phosphoric acid, and 13,400 pounds of potash. A yield of 14 bushels of wheat per acre—said to be the average yield in America—would remove 29.7 pounds of nitrogen, 9.5 pounds of phosphoric acid, and 13.7 pounds of potash. If all the potential nitrogen, phosphoric acid and potash present in the first eight inches of average soil could be rendered available, there would be enough nitrogen to last 90 years, enough phosphoric acid for 500 years, and enough potash for 1,000 years. It is, however, impossible for the farmer to render all this potential food material available, hence it is quite possible for a soil to be rich in *potential* food elements yet produce barren results.

A soil at Rothamsted, which had been cropped to grain for several years without the addition of manure and had become exhausted, was found to contain 2,880 pounds of phosphoric acid per acre, but only 72 pounds per acre were in an available form. That is, a soil which contained theoretically enough phosphoric acid to supply a wheat crop for 300 years, had only sufficient available for about seven years.

There is little cause for alarm of famine as regards phosphates and potash, for there are practically unlimited and cheap sources of supply of these elements to draw upon for restoring the loss due to cropping. With nitrogen, however, it is quite different. The nitrogen naturally present in the soil is chiefly in the form of organic compounds. This organic nitrogen is converted by the nitrifying bacteria into nitrate nitrogen before being available for plant food, and is then removed from the soil by the crops grown thereon, or washed out and lost in the drainage waters.

Unfortunately, the supply of combined nitrogen in the universe is limited, and the two richest sources—guano and nitrate beds—are being rapidly exhausted. The guano deposits have already almost given out, and it is estimated that, at the present rate of consumption, the nitrate beds will not last for more than 40 years. Hence it may be truly said that the nitrogen problem is one of the gravest importance.

Recently, much has been heard concerning the manufacture of lime-nitrogen, as it is called, by means of electricity. This source, whilst allaying all fears of a nitrogen famine, is too expensive at present for general farming.

What is wanted is a cheap supply, and modern science has revealed this by showing the ability of leguminous plants, when in association with certain bacteria, to utilise the inexhaustible store of atmospheric nitrogen, and add large quantities of combined nitrogen to the soil.

It has been calculated that there are about 75,000,000 pounds of atmospheric nitrogen above every acre of land of the earth's surface. Taking the value of nitrate of soda, containing 16 per cent. of nitrogen, at eight shillings per 100 pounds, the commercial value of one pound of nitrogen would be sixpence. At this valuation there is nearly £2,000,000 worth of nitrogen above every acre of land, free and waiting to be utilised!

How can it be done? Well, Nature has revealed to us the way, and shows how by means of those wonder working agents of hers—bacteria—it is possible to obtain practically unlimited quantities of nitrogen from the air for the use of farm crops, at a very small cost. These bacteria live in the nodules or tubercles which are found upon the roots of all leguminous plants (peas, beans, clover, lucerne, &c.). There they multiply and absorb the free nitrogen from the air, and cause it to unite with other elements to form compounds which are suitable for plant food.

From the earliest days of Agriculture it has been recognised that the growing of leguminous crops had a beneficial effect upon the soil. Pliny wrote: "The bean ranks first among the legumes. It

fertilises the ground in which it has been sown as well as any manure," and there are many references in ancient writings to the necessity for including some leguminous crops in the regular rotation.

The meaning of this was not understood until quite recent times, when in 1886 Hellriegel demonstrated that these plants somehow obtain their nitrogen from the air, and their growth in soil free from nitrogen compounds depends upon the presence of the nodules upon their roots. That is, tubercle formation and nitrogen assimilation by the plant were interdependent—the more numerous the tubercles the more vigorous were the plants owing to the increased amount of nitrogen absorbed.

In 1887, Prof. Marshall Ward traced the development of the tubercles, from the infection of the root hairs of plant by some organism in the soil up to the formation of the mature nodule, and showed that the tubercles could be produced at will by the inoculation of roots with soil infusions.

In 1888 Beyerinck obtained a pure culture of the root-tubercle organism on artificial media, and named it *Bacillus Radicicola*.

In 1890 Prazmowski succeeded in inoculating the roots of bean plants growing in sterilised soils, and obtaining luxuriant growth by simply watering the plants with a liquid culture of the organism. From this point the question of tubercle formation and inoculation passed from one of mere botanical interest to one of great agricultural importance.

Prof. Nobbe, of Germany, was the first to attempt the inoculation of soils by means of pure cultures on a large scale. He isolated the organisms from the tubercles of a number of leguminous plants, then planted them in bottles containing nutrient gelatine, and sold them under the trade name of "Nitragin." Unfortunately, Nitragin did not prove a success. In a certain number of cases, satisfactory results were obtained from its use, but eventually the proportion of failures was so numerous that its manufacture was given up. The difficulty appeared to be in preparing cultures of the right virulence which would not deteriorate during transit. Nobbe's principle of inoculation was sound, but he had not devised the correct method of application.

In 1901 the United States Department of Agriculture commenced " a scientific investigation of the root-nodule organism, with " a view to making practicable for use in the United States the pure- " culture method of inoculation."

It was soon discovered why Prof. Nobbe's methods of culture and distribution were so uncertain in their results. The work in life of the nodule bacteria is to absorb and fix the *free* nitrogen from the atmosphere. When grown in Nobbe's gelatine medium they

naturally preferred to feed on the *combined* nitrogen in the gelatine, consequently they became overfed and lazy, and lost their virulence, so that when distributed in the soil most of them had lost their power of attacking leguminous plants and forming nodules. The American investigators worked out improved methods of making the cultures, and demonstrated that if the organisms were grown in a non-nitrogenous medium their nitrogen-fixing power was increased, and in this condition, when dried on cotton wool, they could easily be distributed. After two years of experiment, the United States Government considered the results justified distribution of the inoculating material on a large scale. During 1903 and 1904 over 12,000 packages were sent out free to farmers in the various States. In January, 1905, a report of the results obtained was published which shows that 74 per cent. of the trials were successful, that is, gave an increase of crop as the result of inoculation.

These satisfactory results naturally attracted much attention, and in 1905 the Board of Agriculture and Fisheries of this country "obtained the co-operation of 13 different agricultural colleges and "experiment stations with a view of testing the cultures." The results of these experiments were published in the Journal of the Board of Agriculture for February, 1906, and show that "the nega-"tive results exceed the positive in number both in plot experiments "and under agricultural conditions." The report sums up as follows:—

"As a result of all the reported experiments, it seems evident "that the cultures used were not uniform; it is not possible, how-"ever, to determine the extent to which the failures are to be attri-"buted to this cause. It seems, however, from the positive results "recorded, that not only are these cultures sometimes able to pro-"duce nodules on the roots of plants new to a neighbourhood, but "that even in cases where the leguminous crop had been grown in "the previous year benefit may be derived from inoculation.

"It is quite evident that the subject of plant inoculation in this "country has not yet passed the experimental stage, and more work "is required before one can feel at all justified in recommending "either method for adoption on a field scale; nevertheless, the "positive results obtained may lead farmers to hope that in the "future benefit may be derived, in some instances at least, from the "treatment of the soil, or the seed before sowing, with inoculating "materials preparatory to growing leguminous crops."

And there the Board of Agriculture left this matter. The obtaining of a few samples of inoculating material from America and Germany: the distribution of these samples to various agri-culture colleges and stations; the publication of a report on, in certain cases, dead bacteria! (It seems probable that in some cases

the cultures were dead or in a highly weakened condition. Jour. Bd. Agric., Feb., 1906, p. 658); and the important question of inoculation of leguminous crops is settled as far as the Board of Agriculture is concerned.

Yet, the results obtained by the Board with some of the cultures which chanced to be alive ought to have prompted it to undertake the "more work required." In Scotland an acre of inoculated beans yielded 3,070 lbs. of grain, against 1,800 lbs. from an acre non-inoculated; a gain of 70 per cent. In Leicestershire, ½ acre plot of treated peas yielded when threshed 108 stones, ½ acre plot untreated only 66 stones. At Woburn, treated *Melilotus* gave 23 per cent. heavier crop than untreated. At Aberdeen, "on a farm where the soil is peaty, and clover had never grown well, the treatment has been remarkably successful, producing a thicker covering of clover and a much stronger growth. The difference has increased between October and the present time in an extraordinary way."

Surely these results ought to have convinced the Board that inoculation was of sufficient importance as to demand immediate and further investigation.

Yet nothing has been done by the Board since! The officials of the Board are, of course, not to be blamed for this state of affairs. They cannot go beyond their powers. The blame rests entirely upon the Government which ought to have recognised the national importance of the subject, and provided the necessary funds and machinery for a complete and thorough investigation.

During the winter of 1905, research work on some unsolved problems in the life-history of the nitrogen-fixing organism, had been in progress at the Botanical Laboratory, King's College, London, and the experiments of the Board of Agriculture had been followed with keen interest. In the spring of 1906, when it was found that the Board did not intend to follow the subject further much disappointment was felt, and, eventually, after considerable hesitancy, it was decided to distribute such of the pure cultures from the King's College experiments as were suitable and available for inoculation, and thus continue within the narrow limits of time and means at disposal, the work which ought to have been carried out by the Board of Agriculture.

In the autumn of 1905 a bulletin had been published by the New York State Experiment Station showing the inability of the nitrogen-fixing organism to retain its vitality for any considerable time when dried on cotton wool—from six weeks to two months being the limit in most cases. Failure followed each attempt to develop cultures of the organism from the commercial cotton cultures. These failures could not be ascribed to the laboratory

methods employed, since the method was uniformly successful when laboratory cultures of the organism were used in the place of cotton cultures. The failure of these cultures was due to "the inability of the nitrogen-fixing organism, under ordinary atmospheric condition to maintain itself upon the cotton for any considerable time. While our results explain the many failures from the use of cotton cultures, they should not be understood as being opposed to the idea of treating the seed of legumes with living bacteria." Little wonder that the Board of Agriculture obtained so many negative results when in their report we find stated "that in some cases the cultures were received from Washington in the autumn of 1904, but were not used till the following spring." In this connection it is interesting to note that the American Government has given up the use of cotton wool as a medium for distribution, and now sends out the pure cultures in liquid form in bottles.

When it was decided to send out inoculating material from the Botanical Laboratory at King's College, it was necessary, in view of the New York experiments, to find some other medium than cotton wool for distribution of the pure cultures. After a number of experiments it was found possible to obtain a powder preparation of the bacteria, in which condition they retain their vitality for months. Some are still active after being kept for two years.

During 1906 and 1907 over a thousand packages of this preparation have been distributed *free* to any one who cared to test inoculation of seed or soil, with the gratifying result that over 80 per cent. of the reports returned show an increase of crop from its use.

At this point it will be well to utter a warning against any misconception or unjustifiable expectations regarding the use of bacterial cultures. Inoculation is not a panacea for all soil ills. The cultures are not a manure, they simply add to the soil the nitrogen-fixing bacteria which are essential for the most successful growing of leguminous crops, and this only when certain soil conditions are favourable. Last year a trade circular in America advertised bacteria cultures under the startling headings—

THE GREATEST DISCOVERY OF THE AGE!

VACCINATING THE GROUND.

INSURES CROPS OF LEGUMINOUS PLANTS ON ALL SOILS.

DOUBLES THE YIELD.

Now, to put it mildly, these statements are utterly misleading. It is not true that inoculation insures crops of legumes on *all* soils, nor will it always double the yield. Failure of the crops may be due to soil acidity. It may be due to insufficient plant food—phosphates and potash. It may be due to unfavourable physical conditions of

the soil, or lack of proper drainage. It may be due to an unfavourable season, or bad seed. In none of these cases would inoculation remedy affairs, and the farmer who purposes inoculating his seed or soil must carefully inform himself as to the conditions and requirements of his land.

To begin with, it should be clearly understood that the nodule-forming bacteria supply nitrogen only to the crops and soil. If the land is deficient in phosphates, potash, or lime, these must be added if the bacteria are to do their work properly. Plants require phosphates, potash and lime as well as nitrogen for healthy and vigorous growth, but nitrogen is the most important as well as most expensive food element, and given the presence of the other food elements in the soil, inoculation will supply all the nitrogen necessary for the luxuriant growth of a leguminous crop even in such an unlikely medium as sterilised sand. A fine crop of Mexican beans has been grown in volcanic ash from Guatemala in King's College laboratory by simply adding culture solution to the ash.

Cinders can hardly be considered an ideal soil, yet an experimenter reports :—" We also sowed inoculated sweet peas on a cinder path at the top of a low wall, and they have grown and blossomed very freely, and looked very nice hanging over and covering the wall. Our friends have been quite astonished to see them growing in cinders."

Another point to be remembered concerning inoculation is that soils rich in available nitrogen do not respond to inoculation. Where plants can obtain nitrates from the soil they appear to prefer this source of nitrogen supply, and tubercle formation is prevented. The fact that tubercles are not found in any quantity upon plants growing in rich soils has been frequently observed. Prof. Vines demonstrated some years ago that the presence of nitrates in the soil has an unfavourable effect upon the nitrogen-fixing bacteria, and that there is a definite relation between the amount of nitrates present and the number of root-nodules. He states :—" The results of all these experiments agree in showing that the development of tubercles is much less when nitrate is present in the soil than when it is absent. It is also indicated that as the amount of nitrate diminishes, the development of tubercles becomes more marked. In all cases in which tubercles made their appearance on the roots of plants which had been supplied with nitrate, they are exclusively developed on the youngest roots, especially on those near the surface of the sand ; in that part of the soil, that is, which would naturally lose its nitrates most rapidly."

It cannot be too strongly emphasised that the cultures of nitrogen-fixing bacteria are not to be regarded in the light of nitrogenous

fertilisers, increasing the yield under any or all conditions. The cultures do not contain nitrogen. They simply add to the soil the bacteria which, under favourable conditions, form nodules on leguminous plants, and render available the nitrogen from the atmosphere for the growth of these plants. As already pointed out, rich soil containing plenty of available nitrogen checks the activities of the bacteria. It is poor soil which responds most readily and liberally to inoculation; the thousands of acres of non-productive land it does not pay at present to till and manure, which can be restored to fertility and productiveness by the use of these bacteria cultures.

What then are the conditions under which a farmer may expect to benefit by inoculation? Inoculation is *necessary* when the land is poor or "thin," that is, low in organic matter, and has not recently borne a leguminous crop, or when the roots of legumes grown are devoid of nodules. Inoculation is *desirable* when a different leguminous crop from that previously grown on the land is being planted; or when the crop growing, though possessing root nodules, is not producing up to the average. The introduction into the soil of a more virulent race of bacteria may greatly increase the yield.

Inoculation is *useless* when the legumes usually grown are producing high yields and the roots show nodules in abundance; or when the soil is rich in available nitrogen, for under this condition few nodules would be formed.

Inoculation will be a *failure*—

1. When the directions for preparing the culture solutions are not carefully followed.
2. When the soil is too acid and in need of lime. Liming to correct acidity is as necessary for the proper activity of the bacteria in the soil as for the growth of the plants.
3. When the soil is deficient in phosphates and potash, these fertilising elements must be added if the bacteria are to perform their work properly.
4. It must also be remembered that inoculation will not overcome results due to bad seed, improper preparation and cultivation of the ground, and adverse conditions of weather or climate.

Given suitable conditions the advantages which may be expected from inoculation are—

1. Increased yield of leguminous crop.
2. Improvement of land for succeeding crops, by adding organic nitrogen to the soil.

3. Increase of nitrogenous contents of inoculated plants, which means increase of feeding value.

4. In many cases hastened maturing of plants, thus allowing of earlier marketing of produce with enhanced value.

1. Increased Yield.—The amount of increase will naturally vary according to differing conditions, and it is evident from what has been already stated that the greatest increase may be expected on poor or worn-out soils. This is especially noticeable from some of the American results. One report states that "worthless, barren ground, literally too poor to grow weeds, has been inoculated and made to produce crops four times as large as those taken from average uninoculated soils. A Maryland farmer, who had been obliged to abandon two-thirds of his farm because it was 'worked out,' increased his output 500 per cent., simply by inoculating his soils. Scores of similarly abandoned farms have been reclaimed."

As regards the soils of this country, it is often said that "they are too good to respond to or need inoculation." One writer recently stated that "ninety-nine per cent. of our soils have all the microbes they need." But the results given on pages 16 to 29 show how erroneous such statements as these are, and indicate that in this country also there are immense possibilities in seed and soil inoculation for increasing the yield of crops. Comparative weights of inoculated and non-inoculated yields have been given in only a few cases in the reports sent in, but estimates of "50 per cent. more," "double the crop," "three times as good," show what may be expected from inoculation. One of the most striking results is reported by a "small-holder" near Gloucester, and is of special interest just now when the subject of "Small Holdings" is so much in evidence. He reports (see p. 18 for full account):—"From a quarter of an acre of peas *inoculated* I picked 33¾ pots (42 lbs. to the pot), selling them for £7 18s. 9d. From a quarter of acre *not inoculated* but dressed with 1 cwt. superphosphate and ½ cwt. sulphate of potash, I picked only 14 pots, selling them for £2 5s. 6d." That is, inoculation for less than a quarter the cost of the artificials used gave him an increase of £5 13s. 3d.!

2. Increase of Fertility of Soil.—That leguminous crops effect a marked benefit on the yield of succeeding crops is so well known, that it is the practice of every farmer who wishes to maintain the fertility of his soil, to include some leguminous crop in his rotation of crops. It can easily be demonstrated that the greater part of this benefit is due to the organic nitrogen supplied by the root-nodules, and that unless the nodules are present the leguminous crop actually exhausts the soil instead of improving it. It has already been pointed out that the nodules are the centres of nitrogen-fixation.

In their tissues are stored up quantities of organic nitrogen greatly in excess of what is required by the leguminous plant. When the crop is harvested these nodules remain in the ground, and the nitrogen store of the soil is correspondingly increased.

A number of careful experiments have been made in the United States and Germany to estimate the approximate amount of organic nitrogen added to the soil by a well grown leguminous crop. Averaging the results from sixteen different States in America, the amount of nitrogen added per acre was 125 pounds. In Germany the estimate was 175 to 200 pounds per acre. When it is considered that nitrate of soda contains only about 15 per cent. of nitrogen, it is seen that a crop of nodule-bearing legumes may add the equivalent of half a ton of nitrate of soda per acre, representing a cash value of £4 to £6.

It must be remembered, however, that it is only when the roots of the legumes are plentifully supplied with nodules that this nitrogen is added to the soil. It is quite possible to grow good crops of legumes by the aid of manure without nodules being formed. But in this case the soil is being impoverished instead of enriched for the subsequent crop, and the nitrogen taken out by the leguminous crop must be restored in the form of expensive manures. When, however, the nodules are abundantly developed, as may be obtained by inoculation, not only is the leguminous crop largely increased, but the soil is *richer* and *better* at the end of the season than it was before the crop was planted, and the succeeding non-leguminous crops produce a largely increased yield. Careful experiments made in America give the following statistics :—

	Original Yield per acre.	Yield per acre after Inoculated Crop.	Gain per cent.
Potatoes ..	67.8 bushels ...	102.2 bushels ... after crimson clover	50
Oats ...	8.4 bushels ...	33.6 bushels ... after velvet beans	300
Rye ...	4.5 bushels ...	23.5 bushels ... after peas	400
Wheat ..	18.6 bushels ..	26.9 bushels ... after melilotus	46

3. Increase of Feeding Value of Crop.—It sometimes happens in inoculation experiments that there is no evident difference in the yield from inoculated and non-inoculated plots. Now a visual comparison is apt to be misleading, and the only accurate way of obtaining results is by weighing the produce. This is well seen in the report from Grappenhall, where a crop that showed

no appreciable difference to the eye, weighed 30 per cent. more than the non-inoculated.

But even when weights are equal, the inoculated crop is more valuable that the non-inoculated, because of the increased nitrogen contents. Experiments made at King's College during 1906 demonstrated this fact conclusively. Tares were grown in sterilised soil, to which the requisite potash and phosphate salts were added. In one set of pots nitrate of soda was also added proportionate to 2 cwt. per acre; the other set of pots was inoculated. At the end of the season equal weights of produce from each set were taken and analysed for their nitrogen contents, and results found to be as follows :—

Tares, with nitrate of soda	..	1.92 per cent. of nitrogen.
Tares, inoculated ..	..	3.07 ,, ,,

Thus the inoculated tares contained 50 per cent. more nitrogen, that is, was half as rich again in feeding value compared with that grown with nitrate of soda. An analysis of the lucerne from the field experiments at Kilmarnock, mentioned on page 29, show similar results. Equal weights of produce gave—

Section A, no nitrogenous manure	..	3·41 per cent. nitrogen.
Section B, 2 cwt. nitrate soda	..	3·75 ,, ,,
Section C, inoculated ..	..	4·04 ,, ,,

Here the difference was less marked than in the case of the tares, the reason being that the plants from the two non-inoculated plots were all found to posess a few nodules on their roots. Still even in this case, the increase in feeding value would more than repay any cost and trouble of inoculation, apart from the 30 per cent. increase of crop. These results also show that the dislike of buyers of hay to what they term "nitrate" hay is well founded, and they are quite accurate when they say that such has less substance in it than that grown in the ordinary way.

4. Early Maturing of Crop.—A striking fact brought out by the experiments during the last two years is that, in a number of cases, inoculation has hastened the maturing of the crop very materially. Reference to the reports shows that "ten days," "a fortnight" and "three weeks" are given for earlier ripening of inoculated crop. With early crops this means earlier marketing and enhanced prices, a matter of the greatest importance to growers.

One of the most surprising results in this connection comes from Guernsey, where a large firm of growers reports on inoculation of kidney beans under glass as follows —"The beans were grown with the material you were kind enough to send us, and we may

say that we have never had a better and earlier crop. The seeds came up very strong, and the leaves had a nice dark colour. We picked the first beans *six weeks after sowing*."

To the farmer who reads of the wonders worked by soil inoculation, the question naturally arises—"How is it done?"

The method is simplicity itself. Given ordinary common sense and care, there is not the slightest difficulty in preparing the culture solutions from the materials supplied. Neither elaborate appliances nor special knowledge are required. The "suitable temperature" has caused anxiety to some users, but if it be remembered that a temperature similar to that necessary for the "working" of yeast when mixed in the sponge by the housewife, is all that is required there ought to be no difficulty in obtaining the cloudy solution. The results given in the reports which follow have all been obtained under the general conditions to be found upon any farm or garden.

The cultures were distributed as far as possible to everyone who was sufficiently interested in the subject to write for material. With the material the instructions given below were sent, from which it will be readily seen that the preparation and application of the culture solution of nitrogen-fixing bacteria present no difficulty:—

Directions for using Inoculating Material.

The contents of the accompanying packages will produce one gallon of culture solution. A smaller quantity may be prepared by using proportionate quantities of the materials.

Take a bucket or tub, clean and scald it out thoroughly, place in it one gallon of good pure water (preferably rain water which has been well boiled and allowed to cool), add the contents of package No. 1 and stir until the salts are dissolved. Then carefully open package No. 2, and drop the enclosed wool and powder into the solution, giving another stir. Cover the tub with a clean moist cloth to protect the solution from dust, and keep in a warm place (*e.g.* by the side of a fire), *but temperature must not exceed* 75° *to* 80° *Fahr.*

After 24 hours add the contents of package No. 3, again stirring and allow the mixture to stand until it turns cloudy. This will take place in from 24 to 36 hours if the temperature is suitable. If the solution has been kept cold, further time should be given (not exceeding one or two days) for sufficient growth of the bacteria to produce the cloudiness, as it is useless for inoculating purposes until it turns cloudy.

To Inoculate Seed.—Take enough cloudy culture solution to moisten the seed. This may be done either by dipping the seed

in the solution, or by sprinkling the solution on the seed and turning until all the seeds are moistened. Seeds should not be *soaked* in the solution, but merely *moistened*. Then spread out the seeds in a shady place (never in direct sunshine) until they are perfectly dry, Plant just as you would ordinary seed. If thoroughly dried the inoculated seed will keep for several weeks, but the cul'ure solution must be used fresh, as it will not keep, after ready for use, more than 48 hours.

To Inoculate Soil.—Dilute the cloudy culture solution with an equal quantity of water, then take enough dry soil so that the solution will merely moisten it. Mix thoroughly so that all the particles of soil are moistened. Thoroughly mix this soil with four or five times as much soil, then spread thinly and evenly over the prepared ground just as if spreading a fertiliser, and rake or harrow in immediately. If used as a top dressing for growing crops, it must be applied in showery weather, so that the bacteria may be washed down to the roots of the plants.

To Inoculate Growing Crops.—Mix 1 part culture solution and 50 parts water—say ½ pint culture solution to 3 gallons water—and apply directly to roots of plants by means of a watering can in gardens and water cart in fields.

In gardens where only a small amount of culture solution is required for seed inoculation it is best to take a proportion of the materials—say one-quarter, and produce one quart of culture solution for the seeds. Then when the plants are from 3 to 6 inches high prepare the remainder (3 quarts) and apply diluted as above directly to the roots.

This double inoculation will give the best results.

It was scarcely to be expected that reports would be sent in by all experimenters, even though the material was *given* to them. But it was annoying to learn, in view of the fact that hundreds of applications had to be refused, that in several cases the material was never used. One may perhaps understand the timidity of the dainty lady, who when she found the bacteria were alive "was afraid to put them in the soil lest they should get into the plants and then into the human body." But one can only deplore the selfishness of those who, "after reading the directions, considered the thing too much trouble to bother with!" This experience may be used as an argument against a "free" or even "cheap" distribution of the inoculating material. Things easily attained are rarely valued highly, and there appears to be some sense in the remark made by a landowner when discussing recently the possibilities of the material being distributed "free" by the Board of Agriculture—"Make the farmers pay for it; they will value and appreciate it all the more."

A very large number of reports have, however, been received, and it is very gratifying to find that over 80 per cent. of these show an evident advantage from inoculation. Of course, successful results could not be expected in every case. The material was distributed practically broadcast, in order of application, without selection of locality, or conditions, or persons. Under these circumstances, it is surprising that the percentage of failures is so small. Even the nitrogen-fixing organisers cannot fulfil their mission in the face of prejudice, ignorance and carelessness. Three illustrations of what is meant may be given. One, an artificial manure dealer, evidently not without bias, reports, "the stuff is no earthly good!" Another "soaked the seeds in solution for three days," although the directions explicitly state—seeds should not be *soaked* but merely *moistened*. Whilst a third tries inoculation on "soil deep dug, with added horse and cow manure, while occasional syringing of the plants with dilute solution of nitrate of soda (varied once or twice with sulphate of ammonia) has been indulged in."

The following selections from the reports received are given as showing the possibilities of soil inoculation under widely differing conditions of culture and soil. They are classified according to counties, in order to be more readily available to those interested in the results from a given district :—

CORNWALL.

MARAZION. *Peas.*—The peas were a great success. Inoculation of soil *and* seed returned a good 30 per cent. more than only seed inoculation, and the seed inoculation showed a good 20 per cent. better crop than the farmyard manured peas. Inoculation in both cases rendered a *fortnight earlier marketing* possible over the manured.

CHESHIRE.

CHESTER. *Peas.*—Taking a piece of poor ground in an old garden we planted one portion with inoculated seed, and in another portion inoculated the soil. Against this and adjoining we sowed the same kind of peas untreated, half upon ground treated with ordinary farmyard manure, the other half with a little bone manure in addition. As regards the result it was easily discernible which peas had been treated, the foliage being stronger, and the pods larger and more freely produced than those grown on the manured ground.

CHILDER THORNTON. *Clover.*—They have just begun cutting the oats, and are very pleased with the inoculated clover; it is almost too good, very strong plants.

HALE. *Sweet Peas.*—The inoculation of my sweet peas has been an immense success. Unfortunately the unfavourable weather this summer prevented me showing in London on July 16th, but with blooms 2¼ inches across, and stems 18 inches long in addition to numerous four blooms per stem (very few less than three), I can say with confidence that there were none better. Whilst in this district and Manchester they have been generally remarked upon. From the very commencement of operations the inoculated seeds shewed more vigour than the others.

DORSET.

WEYMOUTH. *Peas.*—For experiment with peas I sowed ⅓ without, and ⅔ with culture treatment to seeds previous to planting. Results as follows :—

1. Stages of early growth little difference.
2. As soon as flower blooms appeared the haulms of " culture " gained considerably in strength, height and show of blossom.
3. Pods of " culture " fairly 20 per cent. better—both in size and quantity.
4. Flavour decidedly superior to " non " treated.
5. A few haulms of " culture " bore pods of far larger size than the type.

DEVON.

TAVISTOCK. *Clover.*—The inoculated clover was taller by three inches than the uninoculated.

DENBIGHSHIRE.

WREXHAM. *Sweet Peas.*—Inoculation has been quite a success. The flowers are greater in number by at least 20 per cent, than those not treated, and the size of the flowers is much larger.

ESSEX.

EPPING. *Peas.*—First sown peas, inoculated, a fine crop with haulms of great thickness and fruit large and juiey. Second sowing, uninoculated, results very poor, haulm thin and weakly, crop almost useless. The ground on which first crop was sown had had no peas on it for several years, whereas the ground on which second crop was sown had had peas grown on it in the previous year.

CHAPPEL. *Sweet Peas.*—The inoculating material you sent me was a distinct success. The sweet peas started to blossom earlier than the non-inoculated and grew two feet higher. I gained three prizes with them in open classes at local shows. My soil is very light and shallow, and was never cultivated until two years ago, and numbers of people have been surprised at my display of sweet peas on such poor ground.

WOODFORD. *Peas.*—Seeds treated; plants also watered with solution at later period of growth. The treated peas show a very much more vigorous growth, and much better yield of fruit.

HORNCHURCH. *Peas.*—The row which I treated with your preparation seems generally stronger and certainly earlier than the others. As regards earliness the row treated, although planted out a fortnight later, began to flower before those not treated.

GLOUCESTERSHIRE.

STAUNTON. *Vetches.*—The inoculated were greener and thicker than those not treated.

Broad Beans.—The inoculated were up a week and a half before those not treated, and were very much greener, and more weight.

2 rows *inoculated*, 65 yards long, gave 4¼ pots.

2 ,, *not inoculated* ,, ,, ,, 3 ,,

a gain nearly half as much again, 1¼ pots, or 52 lbs., a pot being 42 lbs.

Peas.—The inoculated peas were a great success. They were from the beginning very much greener than those not dressed, and the pods were ½ to 1 inch longer, and much larger peas. I had the best crop of peas round here for 2 or 3 miles, and was the first to sell to the greengrocers in Gloucester in quantities. From a quarter of an acre planted with 1 bushel *inoculated* seed I picked 33¾ pots (42 lbs. to the pot); selling them for £7 18s. 9d. From a quarter of an acre planted with 1 bushel *non-inoculated* seed but dressed with 1 cwt. superphosphate and ½ cwt. sulphate of potash, I picked only 14 pots, selling them for £2 5s. 6d. I also planted a quarter of an acre with 1 bushel inoculated seed, and manured with ½ cwt. super., and ½ cwt. sulphate, and picked 54¼ pots selling for.

This village is composed of about 80 small holdings from 2 to 4 acres, and most of the people grow market garden stuff. They were surprised at me being able to pick so much off the small amount of ground. I shall be pleased to obtain more inoculation material next year when I want to try it on some heavy clay land which is very poor and has been laid down 2 years.

GUERNSEY.

RAMEE. *Runner Beans.*—The beans were grown with the material you were kind enough to send us, and we may say that we have never had a better and earlier crop. The seeds came up very strong, and the leaves had a nice dark colour. We picked the first beans *six weeks after sowing.*

A more detailed report states:—On October 5th, 1906, we planted the house with beans which did not crop very well. The house is 200 feet long and 30 feet wide. This crop was finished on February 21st, 1907. We then cleaned the house, burned some sulphur, washed the glass, and trenched the ground about 18 inches deep, and worked in 2 cwt. pulverised chalk, and 1¼ cwt. Cross's organic manure. We replanted the house with *inoculated* seed on February 22nd, and our first beans were sent to market on April 8th. We can assure you beans have never before done so well in our ground.

HANTS.

WINCHESTER. *Peas.*—The inoculated peas are growing and bearing well, especially as none of them were manured. My opinion is that inoculation is a great help on such poor soils as mine.

JERSEY.

ST. OUEN'S. *Lucerne.*—The inoculated seed came up better than the untreated, and the crop is now a lot thicker and of more even growth.

Peas.—I found the culture increased the pea crop a great deal, and they were at least a week earlier than the non-inoculated. The land is very poor gravelly soil.

KENT.

FAVERSHAM. *Clover.*—Culture applied by being mixed with earth, then spread and harrowed. Treated half acre yielded 2½ waggon loads of clover fodder ; untreated, 2 loads. The clover on the treated part was stouter and larger than on untreated. Soil rather thin near the chalk.

BECKENHAM. *Sweet Peas.*—I have not grown sweet peas before this year, and therefore cannot compare with any previous results. I may say, however, that my plants have excited the admiration of my friends. I treated the seeds with your culture, and some of the plants have run up to 8 feet in height. The flower stalks have been in some cases 16 inches long, and while threes have been general, there have been several fours, the blooms being of fine size.

LYMINGE. *Peas.*—The peas greatly benefitted by your inoculating process. I had as many as 13 peas in a pod, and the general run of the pods contained 8 or 9.

CANTERBURY. *Beans.*—Strip 20 furrows wide through centre of field sown with seed not dressed yielded 11 bushels 5 gallons ; strip 20 furrows wide (above) sown with *inoculated* seed yielded 14 bushels 1 gallon ; similar strip (below) yielded 14 bushels 7 gallons. The whole of the field where seed was treated gave a yield of 6 quarters 2 bushels, which was very good indeed for such poor land, and speaks very well indeed for the farms you so kindly set to work on our account. Now that this has been such a success, may I hope you will kindly furnish me with some more bacteria for the coming year, or tell me how I can obtain it.

LANCASHIRE.

GRAPPENHALL. *Beans*—I had a bed inoculated and one without. In early stages those inoculated seemed the stronger plants, but at maturity there did not seem much difference ; but I shelled them myself, and consider those inoculated yielded fully 30 per cent. more than those non-inoculated. I planted them in ground that had no manure for two years, and I consider the results very satisfactory.

WHALLEY RANGE. *Peas.* The plot treated with culture was approximately a fortnight in advance of a similar plot planted with untreated seed. The plants are exceptionally good.

Sweet Peas—Seeds which were treated did exceptionally well, growing plants a third higher than similar seeds untreated. Also on the plants which have been treated with culture, I notice an unusually large proportion of flowers with fours and occasionally fives on one stem.

LEICESTERSHIRE.

DESFORD. *Peas*—The crop is 20 per cent. better on the [redacted]-treated peas. The haulm is much more robust and healthier in appearance also, and flowers are still being produced, while the non-inoculated plot is over.

LINCOLNSHIRE.

WOODHALL SPA. *Green Peas and Sweet Peas*—Inoculated were most successful ; uninoculated but a poor crop.

Scarlet Runners promise a full crop, though growing in very poor sandy soil—in fact, little more than sand. They are certainly as prosperous, if not more so, than the non-inoculated plants in manured soil.

MIDDLESEX.

WHITTON. *Peas*—The results of treating the peas with bacteria have been eminently satisfactory. My experience was as follows :—

"Gradus," *without inoculation*, a fair crop, but they were soon over.

"Sutton's A1," *inoculated*, heavy crop, with abundance of well-filled pods.

"Veitch Perfection," *inoculated*, a very heavy haulm packed with pods, so much so that the weight of the crop broke the haulm down though they were "re-sticked."

"Exhibition," *inoculated*, showed a wonderful crop ; these were so prolific that the haulms broke down under their weight of produce, growing 6 to 7 feet high, with pods 6 and 7 inches long.

All the above were sown in new ground having never grown anything before except grass. I estimate the produce from inoculation was from 30 to 40 per cent. more than from the untreated seed. I was told that my peas were the finest in the district.

HARROW. *Runner Beans*—I tried your system of inoculation upon some runner beans during the past season, and was surprised at the results. The inoculated beans yielded 45 to 50 per cent. more in weight than those grown under ordinary conditions.

NORFOLK.

NORWICH. *Peas*—The inoculated peas were three weeks earlier for market, and decidedly 50 per cent. more prolific than the non-inoculated.

MARSHAM. *Peas*—We made our experiments with the greatest care, inoculating six rows of peas, planting different sorts. In every case the yield from the inoculated rows (we planted 15 rows in all) is *three times* as good as from the uninoculated, the pods hung in clusters, and the yield was excellent, and earlier than we have ever had before.

SWAFFHAM. *Peas*—Result excellent. An exceedingly heavy crop. Beyond this, the most noticeable features about the different varieties are that the inoculated have continued bearing *much longer* than usual, and the almost complete freedom from maggots in the pods, and from any appearance of mildew on the foliage.

NOTTS.

SOUTHWELL. *Clover*—The clover seed was sown on land which before had failed to produce a crop. The treated seed has come up very thick, much better than the untreated, and there is a fine crop.

SHROPSHIRE.

OSWESTRY. *Vetches*—Where the vetches were dressed, your dressing seems to have acted wonderfully, and a fine crop has resulted.

Peas—Our inoculation experiment has turned out a complete success. We have had a splendid crop. The inoculated crop overtook another crop, not inoculated, by four weeks.

BRIDGNORTH. *Peas*—The bacteria culture was very successful. The seed peas were treated strictly according to instructions and I had a check lot of untreated peas sown parallel (and 4 feet away) to the treated peas. The haulm of the treated peas grew very large, and the foliage was fine and remained

clean and healthy. The plants blossomed very freely, and very many pods were produced. In the case of the untreated peas the pods were few, and did not fill well, and the peas produced were not as sweet as those on the treated peas. I gave some of the culture to a friend who was sceptical and gave a grudging consent to its use. He has never before been able to grow a good crop of peas in his garden. This year he says : "The only things to do any good are the peas," so you may rely on it that the culture has done a lot of good.

STAFFORDSHIRE.

TAMWORTH. Agricultural College. *Clover* sown with rye grass inoculation gave an increase of about 15 per cent. *Tares* inoculated shewed an increase of about 10 per cent.

SOMERSET.

BATH. *Sweet Peas*—The inoculation with sweet peas was quite successful, the inoculated seed producing the best flowers that I have ever had, and much stronger than the seed which was not inoculated. Inoculation was by watering the planted seeds. My soil is loam and always kept well manured.

SURREY.

HINDHEAD. *Sweet Peas*—The inoculation experiment has been very satisfactory. We planted the inoculated sweet peas in poor sandy soil which had not previously borne flowers—dug up bracken and heath land. The flowers have been beautiful and plentiful, and at this date when the non-inoculated peas are over, the inoculated are still plentiful and seem to have an unusually sweet odour.

SUTTON. *Sweet Peas*—Some freshly dug meadow land was sown ; one-half the seeds was treated with the solution and the young plants watered as advised, the other half untreated. The treated seeds produced the finest show of flowers we have ever raised, but the young plants from the undressed seeds were unfortunately so badly attacked by slugs and snails as to make comparison useless. Some of the solution was given to a gardener at Carshalton. He divided his seed into two lots—treated and untreated. His soil was a light loam on chalk. The untreated seeds produced a good show of flowers, but the treated seeds did far better. He estimates that the yield of flowers was increased by about a third.

WOKING. *Peas*—The "pea culture" is a great success. Those peas watered with the solution have yielded in an astonishing manner—the yield has been more than double.

Peas. I planted the inoculated peas on land that has not been manured for many years and had a crop of peas quite equal to those grown by a friend on manured soil.

Broad Beans—I had similar results with broad beans, which produced a later growth almost equal to the first.

REDHILL. *Peas*—From one pint of peas inoculated the yield was at the very least 35 to 40 per cent. more than from the pint not treated. We are still gathering from the inoculated peas, and several pods when opened show 8 and 9 peas in each.

Scarlet Runners—The inoculated scarlet runners are quite a sight, reaching the tops of the 8 and 9 feet sticks, and I have had to run strings (like they do hops) to help the runners. The blossoms are a wonderful sight and the lower ones are showing runners of 8 to 10 on one stem.

KNAPP HILL. *Beans*—I am pleased to say that inoculation has been a splendid success. I treated half of each row of broad beans with the solution direct to the roots. The photos I send you show the comparative sizes of the bean pods at the time I commenced to pick them. The inoculated ones were 7¼ to 8 inches long; the non-inoculated only 4½ inches long. I left four of the best plants in both inoculated and non-inoculated plots to grow to maturity. The average length of the pods from the inoculated plants was 11 inches, averaging 8 beans to the pod; the non-inoculated 8½ inches long, with 6 beans. The inoculated beans were quite *three weeks earlier* than the others.

Peas—The peas were treated in the same way, and inoculation was equally successful. The inoculated were ready quite *two weeks* before the others. My garden is old orchard land, and the ground received no manure other than that from the grass which was trenched in about June, 1906.

SUSSEX.

BATTLE. *Clover.*—I sprayed part of a field of grass, cut over each year then pastured, with the culture solution. Now the sprayed part shows a great deal more white clover than the rest of the field. On a piece of very poor land of 7 year old pasture I sowed inoculated white clover seed. The result has been a great improvement in the clover compared with other portion of the field, which had formerly the best clover.

BRIGHTON. *Peas.*—We planted the inoculated peas in the poorest ground we possess, and they have done exeeedingly well.

Sweet Peas.—We also sowed some inoculated sweet peas on a einder path at the top of a low wall, and they have grown and blossomed very freely, and looked very nice hanging over and covering the wall. Our friends have been quite astonished to see them growing in einders.

WILTSHIRE.

CHIPPENHAM. *Peas.*—The experiments have much exceeded my expectations. I applied the eulture at three different periods—at planting seed, and twiee during growth, on a piece of remarkably poor land. They grew half as high again as usual, strong haulm, of lovely deep green, and simply smothered with blossom; peas large and well filled pods—double the usual crop.

Sweet Peas, treated in same manner as peas, have been the admiration and envy of my neighbours, growing from 8 to 9 feet high, and literally a feast of blossom with stems 12 inches and more in length; in bloom early in June, and are still (August 26th) making a brave show. It is truly a wonderful discovery this microbe, and bids fair to revolutionise ideas of gardening.

WORCESTERSHIRE.

EVESHAM. *Peas.*—I am sorry I am unable to give you aceurate comparative results on inoculated and uninoculated plots owing to reasons given below, but in eomparison with my neighbours I eropped, through your assistance, the best return on my peas in the immediate neighbourhood, and they were picked quite *ten days* earlier than others who planted on the same day. Though the land where they were grown is extremely good "black soil," for some reason it will not grow peas, and this is I believe the first time anyone has matured a crop on it.

Lucerne.—I have grown, with the help of your bacteria, a lueerne crop far above the average.

YORKSHIRE.

BRADFORD. *Sweet Peas.*—The sweet pea rows whieh I inoculated twice with your baeteria have been an eye opener to all the other sweet pea growers in this distriet. The ground has had no manure for 3 years, but had a good top dressing of

lime 2 years ago. The foliage, bloom, and height of the plants are far superior to others grown in same district which have been fed with artificials and farm-yard manure.

Peas.—On culinary peas the result has been marvellous. The haulm was very large and thick, and the pods very large and of a lovely dark green colour.

SHEFFIELD. *Runner Beans.*—Inoculated and non-inoculated rows were grown in soil which had had no manure for 10 years. The produce from both lots was carefully weighed, and showed an increase of inoculated over non-inoculated of 43 per cent. Better beans were not to be found in the neighbourhood.

Peas.—The peas were grown on clay soil. Equal quantities of inoculated and non-inoculated peas were sown and yielded: inoculated, 631 pods; non-inoculated, 433 pods; a gain of 45.7 per cent. The inoculated pods were longer and fuller and a *fortnight earlier.*

Sweet Peas.—The inoculated sweet peas bloomed remarkably well, and were the best in the neighbourhood. Nurserymen and market-gardeners came from miles round to see them. They carried off Firsts wherever they were shown, and the proceeds from the sale of flowers were abnormal.

SCOTLAND.

KELSO. *Peas.*—Three quarters of a pound of inoculated pea seed yielded more than 1½ pounds uninoculated; the inoculated peas had larger pods, were better filled, of finer flavour and more uniform in shape than the uninoculated. The inoculated peas gained the 2nd prize at the District Show.

MELSETTER. *Clover.*—I put the inoculation liquid on about a quarter of an acre of grass and clover as a top-dressing. In about a week I could see an improvement, and it (the clover) was far higher and thicker than the rest of the field right on until it was cut. There was double the quantity on it, and it was the same with the aftermath; it came up the second time far thicker and stronger than the rest of the field.

WORMIT (FIFE). *Peas.*—Of those that have already come to maturity, I find that the pods from the inoculated seed are more numerous and much better filled than the pods from seed not treated, the ratio of produce being about 2 to 1.

Beans.—Of the beans I cannot yet speak with certainty as the crop is so late this year, but the pods of the treated portion appear to be filling up much better than the rest.

ELGIN. *Clover.*—The inoculation experiment has been a great success. I sowed the clover with oats. The part I left untreated has been a failure, where treated there is a good crop. I thought when I sowed it, it would have no effect on the corn crop, but only on the grass next year, but I am glad to say that on the top of the field which is inoculated, where the land is very poor and no depth of soil, there is a good crop of oats where it was never anything before. The neighbouring farmers are wondering what I have done to it. On the part of the field I left uninoculated the oats are not nearly so high or so thick as where it is inoculated.

FORRES. *Clover.*—I am glad to say that the crop of inoculated clover is the best we have ever had, quite *double, if not more,* than usual, and it has grown where in one part clover never would grow before. I must congratulate you on your success, and trust I may be allowed to have some more inoculating material next year.

RUTHENGLEN. *Beans.*—On 17th April, 1907, I took 1 lb. 10 oz. of Bunyards' Exhibition Long Pod Beans, of which I planted 1 lb. 6 oz. after inoculating as directed, the other 4 oz. were planted uninoculated at the same time. The former, when from 3 to 4 inches above ground were again inoculated with the dilute solution, the latter were not. The garden slopes to the north pretty steeply, and the soil is heavy clay, which a month before planting had dug into it farm-yard manure in about the proportion of 14 cart loads per acre. Yesterday (Oct. 9th) I took 20 stalks as they came from an inoculated and a non-inoculated row and found the weight of *all* the pods of each were $7\frac{1}{2}$ lbs. and 1 lb. 9 oz. respectively, and of the beans alone $2\frac{3}{4}$ lbs. and $\frac{1}{2}$ lb. The stalks from inoculated seed are quite remarkable for their vigorous growth both in weight and length, and if attention had been given to pruning of side shoots the harvest of pods would, in the end, I feel quite sure, have been appreciably heavier, although even as it is it is quite remarkable. The stalks are still green with a considerable show of blossom, although at this late season they must soon shrivel and die down.

IRELAND.

THURLES. *Clover.*—The inoculation experiment is a great success. All the clover is growing wonderfully thick through the barley, though it is said locally that clover will not grow in this townsland.

KING'S CO. *Peas.*—Inoculated rows have borne most excellent crops, much better than in former years.

Beans.—A very marked difference was shown in growth of the broad beans—those which I had not inoculated being much smaller and fewer.

During the year, reports have come to hand of various experiments in different parts of the country, with inoculating material obtained from abroad. In many cases excellent results have been obtained, as indicated by the three following reports :—

ENGLAND.

ROTHAMSTED. *Clover.*—Land which was known to have carried no leguminous crop for the last 50 years was planted with red clover seed and yielded as follows :—

		Cwts.
Plot A.	Inoculated with Hiltner's preparation from Germany	76.4
,, B.	Inoculated with Moore's preparation from America	72.9
,, C.	Uninoculated	61.9

SCOTLAND.

WEST OF SCOTLAND AGRICULTURAL COLLEGE. *Beans.*—Professor Wright reports :—" On all the farms (five) on which " the inoculation proved beneficial the increase of crop " obtained was enough to give a very satisfactory return for " the labour and cost. An average increase of 304 lbs. grain " per acre as compared with 3½ cwts. of straw shows clearly " that the inoculation, while it gave a larger crop of straw, " increased the yield of beans in a much greater degree, and " hence the effect of this additional treatment has been to " enhance still further the grain-producing character of the " bean crop. The average return, amounting to about 4½ " bushels beans and 3½ cwts. bean straw per acre, would have " formed a sufficient return for a much higher expenditure.

" But, apart from one failure, and making due allowance for " the discrepancies inseparable from field experiments, the " results, on the whole, tend to show that, under suitable " conditions and on ordinary bean soils, the practice of inoculation appears likely to be beneficial and profitable."

Lucerne.—At the College Experiment Station, Kilmarnock, experiments on the inoculation of a growing crop of lucerne have been in progress during the past three years. A growing crop of lucerne was sub-divided into three plots. All received equal dressings of superphosphate and potash; but, as regards nitrogen: A. had no nitrogenous manure; B. was dressed with nitrate of soda at the rate of 2 cwt. per acre. C. was inoculated with culture material from Germany. Last year the green produce from each plot was carefully weighed, and gave:—

	Tons.	Cwts.	Qrs.	
A. No Nitrogen	7	0	3	per acre.
B. 2 cwt. Nitrate Soda	9	8	2	,,
C. Inoculated	12	5	0	,,

IRELAND.

Vetches.—The inoculated seed produced 23 tons of vetches (cut green) per acre, while the uninoculated produced only 11 tons 7 cwts.; showing an increase of 11 tons 13 cwts., or more than double, in favour of inoculation.

And the cost? Well, in America the Agricultural Department of the United States Government is so assured of the national importance of soil inoculation in rendering barren tracts of land fertile and adding to the wealth of the community, that it distributes the inoculating material *free*. But the demand for material is much greater than the Government can at present supply, with the result that the shrewd Yankee business man, seeing the demand, has formed what he calls a "Nitro-Culture" Company and supplies packages of culture material at 10s., which find a ready sale, with agents in this country also who supply "quart" packages for 7s. 6d.

It is, perhaps, too much to expect the Government of this country to take up the manufacture and distribution of the culture material, even though the results of the two years' work at King's College be offered to them free and without cost if they will continue the work. But it would be a thousand pities if the manufacture and distribution got into the hands of the company financiers, whose sole object would be to exploit agriculture in the interests of large dividends. Even run on commercial lines, and paying a good percentage on the capital necessary to run the business, the "gallon" packages could be sold for about 3s. each, whereas the American material now sold in this country costs 30s. for a "gallon." The Board of Agriculture says it has neither the machinery nor the money to undertake the work. But is it quite impossible for these to be found?

For a few thousand pounds the 21 million acres of poor barren land in this country could be made productive and rendered capable of finding work for and supporting such a population that both the food problem and the unemployed problem would be easy of solution.

That this is no wild dream of an enthusiast is shown by recent inoculation results reported from Ireland, on reclamation of waste cutaway bog land in County Mayo. In January, 1906, a top dressing of a mixture of kainit and superphosphate, at the rate of about 5 cwt. per acre, was applied to the heath land, and a chain harrow run over it. At the end of April a mixture of grasses and *inoculated* red clover seeds was sown, followed by a top dressing of soil of about the same quantity as the artificials. At the end of June a most curious crop was to be seen of clover and grasses growing strong and thick through the heather, and in one part of the field through rushes and bent. At the end of August, upon close examination, it was found that the heather was dead at the lower end of the stem, so that a scythe easily went through it, and the whole was mown down. The heather, rushes and bent did not reappear, and by December there was a thick sole of rich herbage, which has this year produced a fine crop of hay. And the farmer reports, "The crops have more than paid for all, and *the land is reclaimed in addition, without a shilling spent on tillage.*"

If the waste places of this country can thus be converted into fertile soil by means of inoculation, surely the subject is worthy the serious attention of our Government.

One gallon of culture solution will inoculate seed for 12 to 15 acres of land, or, when diluted, will, when sprayed or watered on the soil, suffice for an acre or more.

Waste land reclaimed and made fertile for 6d. an acre! Medium soil, when inoculated at a cost of 3s. per acre, yielding 3 tons more produce per acre than when treated with nitrate of soda at a cost of 25s.! Can we afford to neglect such possibilities of national wealth?

TUDOR PRINTING WORKS, CARDIFF.